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RESEARCH ARTICLE

STUDY FOR THE ESTABLISHMENT OF A COMPOSTING AND ORGANIC FERTILIZER PRODUCTION CENTER WITHIN AN AGRI-FOOD FACTORY IN COTE D'IVOIRE

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ABSTRACT

In a context of continuous improvement and sustainable development, industries are part of a dynamic of recycling the waste they produce. This study was carried out on the establishment of a composting and organic fertilizer production center from the waste (mud and ash) produced by the oil mills of a palm oil production company. The first step consisted in quantifying the waste produced. This quantification gave an average ash production of 2.41 tonnes/day and a quantity of sludge of approximately 54.474 tonnes/day. The second step was the choice of composting technology and the process set up for the production of organic fertilizers. The last step was the description of the site, the infrastructure and equipment necessary to guarantee better production and the placing of the organic fertilizers produced at the disposal of the farmers of the region. This study has shown that there is an opportunity to set up a composting unit in the said plant. In addition, the nominal compost production of this center is estimated at 20,000 tonnes per year and that of organic fertilizer is 6,174.34 tonnes per year. The financial indicators including the NPV (net present value or discounted profit), the IRR (the internal rate of return) and the capital recovery time, respectively 20,176,567,240 FCFA, 128.6% and 0.83 years are excellent. The invested capital is recovered after 0.83 years or 8 months 3 days. The project is therefore profitable. In addition, the great flexibility of the supply and delivery of compost and organic fertilizer to the center will secure the production of organic amendment from the region's plantations.

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INTRODUCTION

In a context of continuous improvement and sustainable development, human activity seeks to optimize its constructions as well as possible, to manage its resources responsibly and to minimize its impact on the environment by reducing the pollution resulting from its activity. And waste recovery (1-2). Oil mills are part of this same dynamic by recycling the waste they produce, household waste and treating their effluents before discharge. This work, the theme of which is: "Study for the establishment of a composting and organic fertilizer production center" falls within the framework of industrial waste recovery. This study, carried out at PALMCI's premises, will make it possible to propose the design of a composting center while developing the processes and producing organic fertilizer from the waste generated by the operation of the plant.

MATERIALS AND METHODS

Materials

Several materials were used in the realization of this project. These are among others; a MOULINEX COMPACT brand microwave, used to dry the various samples in order to determine the moisture content of the sludge, capsules for taking the sludge samples. A 0.001g precision OHAUS EXPLORER analytical balance was used for the various weighings and finally the PALM CI EHANIA oil mill control database. The latter reports on the various activities of the UAI D 'EHANIA. Flash, general balance, material balance, material balance rations and many more are stored in this database. It has been of great importance in determining the quantities of waste.

Methodology

This work is purely a study of design, analysis and evaluation. Its achievement is linked to the analysis of data collected from field visits and the use of scientific and technical documents.

Determination of supply quantities from oil mills: The center will treat waste from PALMCI EHANIA oil mills such as stalks, ash and mud. It will also allow the management of household waste. Determining the quantities of this waste will confirm the need for the establishment of a composting and organic fertilizer production center at EHANIA.

Mud: To determine the daily sludge production, a review of the monitoring reports of the waste rations of the central oil mill was carried out for the three oil mills of the Integrated Agricultural Unit of Ehania. The average daily production of sludge from the three oil mills is given by the following formula:

$$M = m_{hc} + m_{a\ \ 1} + m_{a\ \ 2} \quad (1)$$

With: M: Average daily sludge production;
m_{hc}: Average daily production of sludge from the central oil mill;
m_{ant1}: Average daily sludge production from antenna 1;
m_{ant2}: Average daily sludge production from antenna 2.

The moisture content of the sludge was determined as follows: 10 g of sludge is weighed using an analytical balance and then dried to constant weight in a microwave at 540 W for 30 minutes. Five (5) samples of 10 g for each chain were dried in order to obtain a reliable result. The humidity level is calculated using the following formula:

$$H = \frac{m_0 - m_1}{m_0} \times 100 \quad (2)$$

With: H: humidity level; m_o: Mass of the sample before drying; m_1: Mass of the sample after drying.

Determination of dry matter: Knowing the humidity rate and the average mass of the sludge, the amount of daily dry matter is determined by the following formula:

Q = M (100-H) (3) With: Q: Quantity of dry matter (tonnes); M: Mass of sludge (tonnes); H: Humidity rate (4-6).

Ash: The quantification of the ash was done only at the central oil mill since its daily production is more or less equal to the sum of the daily productions of the other two factories. It happened as follows:

The contents of the barrels are poured into the dumpster until they are filled. Subsequently, the skips (full and empty) are weighed using the weighbridge. The difference between the two masses gives the tonnage of the ash. The filling times of these bins were also taken in order to know the ash flow. The quantity of ash found is doubled taking into account the other two boilers of the UAI of EHANIA.

Roundup: The determination of the quantity of cobs produced per day was carried out as follows: First, the monitoring reports of the waste ratios of the material balance of the daily production for six months different from the year 2013 were taken. These are the reports for the months of March through August. These choices are justified in the sense that the months of March, April and May start from the period of high production and the months of June, July and August that of low production. Then, the average daily production of stalks is determined while taking into account the days of operation of the oil mills. Finally, knowing the average stalk production of each oil mill, we determined the quantity of stalks produced per day

$$M \ \ = m_{\ hc} + m_{\ a\ \ 1} + m_{\ a\ \ 2} \quad (4)$$

With:

MR: Average daily stalk production of the three oil mills (tonnes);
$m_{\ hc}$: Average daily production of cobs from the central oil mill (tonnes);
$m_{\ a\ \ 1}$: Average daily harvesting production of antenna 1 (tonnes);
$m_{\ a\ \ 2}$: Average daily harvesting production of antenna 2 (tonnes).

Composting technology chosen for the center: The closed bioreactor process has advantages that are not really required for the planned center. The speed of production is not a basic criterion here. The degree of investment required eliminates this process since the swath and semi-open processes meet the selection criteria at a lower cost. To be operational all year round, tunnel or corridor systems require permanent coverage. They therefore require significant investments in buildings and equipment. With these additional costs, they are less advantageous. The open swath process systems have the advantage of requiring less investment. These systems can be operational twelve (12) months per year if weather protection measures are taken. Compost productions generally meet quality standards. The approach of this process is to operate with basic infrastructure and equipment, used intensively. The secondary data indicate that the windrowing process offers, for comparable quantities, an affordable cost price, depending on the quantity of compost produced, in comparison with the tunnel process and this for the same quality of production. With the selection criteria for the planned center, it becomes obvious to orient the choice towards the windrowing process.

Composting operations: Intended to be operated all year round on a continuous basis, in sometimes extreme climatic conditions, the composting center will have a building whose only functions will be to protect supplies against precipitation and to facilitate operations during rains. . This building will be devoid of any insulation system. The ventilation will be passive, ie there will be no wall on both sides. The single walls existing on the other two sides will protect against the wind. This building is designed to be able to house five windrows 16 m long (7).

Organic fertilizer production process

Receipt and preparation of raw materials: First, the supplies should be weighed before they arrive at the composting center. This will be done using a weighbridge. Then, on arrival at the unit, the truck is recorded by the technician and the weight is recorded in a log. After registration, the truck heads, then to the unloading area set up and delimited by two low walls, that is to say the shed under which the sludge will be dried. Finally, the truck turns around on the weighbridge to be weighed again in order to know its empty weight. Knowing the two weights, namely the weight of the loaded truck and that of its empty, the technician will make a difference in tonnage to know the quantity of mud received by the unit. The trucks transporting the ash bags will undergo the same operations.

Sludge drying: Wet sludge must be dried before proceeding with any other operation. The purpose of drying will be to remove the water contained in the mud. It will also make a perfect blend. In fact, if the sludge is not well dried then there will be mass seizures after mixing and filling the bags. Once dumped, under the hangar, workers will spread it out over a space so that air can circulate freely in the mud. Drying will be done in the shed throughout the year since we are in an area of heavy rainfall. During the dry seasons, some of the mud will be dried under the sun on a landscaped area near the drying shed to increase the amount of dried mud per day and therefore the production of organic fertilizer. At the end of each day, the technician should check the moisture in the mud to see if it is dry. He will take a sample and determine its humidity by drying at constant weight in the microwave. If the humidity of the mud is less than 15% then it is dry, otherwise the mud needs to be dried further (8).

Mud crushing: After drying, the mud becomes compact. It forms hard balls that must be crushed first before continuing operations. Workers will take on this task. They will pound the dried mud in mortars with pestles. A grinder can be used to speed up the grinding process. The ground material must be fine. The grinding will take place under another shed which will also be the place for mixing the organic fertilizer. This land must be in a clean condition, free from all traces of water to avoid contaminating it.

Sieving: Screening is the step of converting organic fertilizer into a commercial product free of impurities. The user of the fertilizer is looking for a healthy product without impurities. Although there is no specific requirement, the market guiding the fineness of the screening reveals a demand for a fine product. While after grinding, not all of the powder particles are the same size. There are also impurities in the ground material. In addition, the ash from the boiler is a mixture of coarse and fine elements. So sieving will separate these elements of different sizes and have a homogeneous mixture. The sieving will be done with a trommel sieve with a particle size of 0-10 mm in order to obtain a fine powder. The composting sieve will be used in addition. It will be carried out under the same shredding hangar to avoid product loss during any transport thereof.

Mixture of mud and ash from the boiler: This step of the process is crucial since it defines the quality of the organic fertilizer delivered to users. Improper mixing of organic fertilizer will adversely affect the plantations and growers' expectations will not be met. To do this, certain precautions must be taken when mixing the different elements. The products to be mixed must be physically and chemically compatible. They must be chemically compatible to avoid any caking caused by hygroscopic increase The fertilizers to be mixed must also be physically compatible, where the granules must have the same size and density as far as possible in order to avoid the phenomenon of segregation during handling, storage and spreading. In order to avoid compositional errors when preparing the mixture, you need to analyze the sludge and ash on the one hand, and the calculations on the other.

Sludge and ash analyzes: The purpose of these analyzes is to determine the composition of each element in order to define the amount of each material required for the mixture. Indeed, it is important to know the mineral composition by weight of a fertilizer in order to be able to correctly determine the amounts of nutrients to apply per hectare. Since the source of the material does not change, a single analysis will suffice for the production of organic fertilizer for several months. This analysis will give the proportion of nutrients (nitrogen, phosphorus, potassium and others) of the sludge and ash (9).

Calculations of the quantities to be mixed: The organic fertilizer produced by the unit will be a mixed fertilizer, that is to say one containing several nutrients. It will be an NPK type fertilizer. The mixture cannot be homogeneous if it is not done with great care.

Put in the bags: Bagging is the last step in the organic fertilizer production process. It will consist of putting the produced fertilizer into 50 kg bags for delivery to users.

Analytical techniques: These analytical techniques will make it possible to follow the composting process throughout its course and to verify the quality of the product obtained.

Temperature: The temperature of each windrow should be measured throughout the composting process by a probe thermometer. The probe, the length of which is at least 1.5 m, is inserted completely from the different sides and at variable depths (0.5; 1; 1.5; 2 m) from the swath (6 times in total) to have the mean temperature of the swath. At the start of the composting process the temperature must be taken every day then every 3 days and during the maturation phase every week. It should be noted that each time a sample of the daily ambient temperature will be necessary in order to make a comparison.

Apparent density: The density is calculated at each step of the process, except for recyclable materials, in order to determine the evolution of degradation and the volume occupied by the waste. A 10 L bucket is weighed empty and then filled with a sample. Weighings are carried out with a precision balance ± 0.250kg. The density value provided is an average of more than 50 measurements. The density d is calculated according to the formula:

$$d = \frac{M}{V} \text{ (Kg/L or T/m}^3\text{)}$$

M: Mass of the sample (Kg) and V: Volume of the bucket (L)

Inert: The inert tests reflect the sum of non-biodegradable contaminants (plastics, glass, metals, etc.). They are carried out on the thinnest part <20 mm of each sample according to the recent Afnor NF U 44-164 standard of January 2004. Other modifications have been made: the particle size separation is carried out on a square mesh of 9.5 and 2.8 mm side. This method is also recommended in the United States by the "US compost Concil", which recommends manual sorting after sieving at 4 mm to separate the plastics. The selection of these mesh diameters is due to the constraints of on-site equipment. The duration of the bleach baths and their numbers have been increased in order to promote better degradation of the M.O. since the analysis is carried out on a fraction of particle sizes <20 mm. Four baths for 2, 4, 14 and 24 hours are carried out in the chlorine solution obtained from calcium hypochlorite.

pH: The determination of the hydrogen potential, pH, is carried out on aqueous suspensions according to the afnor NF ISO 10-390 standard of November 1994. A mass of 20 g of dry matter is dissolved in 100 ml of distilled water. The suspension is homogenized by magnetic stirring for 15 minutes. The pH measurement (± 0.1 pH unit) is done directly by reading on a combined electrode pH meter.

Moisture and dry matter: The humidity (H%) should be determined as quickly as possible, to limit losses by evaporation. Several methods can be used for its determination: the standard oven method or its variants depending on the temperature, the thermo-balance, drying in the open air. The standardized Afnor NFU 44-171 method of October 1982, consists of taking a maximum quantity of sample, preferably a mass greater than 100 ± 0.1g, placed in an oven at 105 ± 2° C until 'at constant weight, about 24 hours. The dry matter (DM%) is the complementary rate of the degree of humidity.

% H = $(M_0-M_1)/M_0 \times 100$; % DM = 100-% H

With: Mo: mass of the raw sample (g); M_1: mass of the sample after passing through the oven (g); % DM: percentage of dry matter contained in the sample; % H: percentage of humidity contained in the sample.

Measurement of organic matter content: A mass of 50 ± 0.1 g is calcined at 550 ° C. for 2 hours in an oven (NF U 44-160 of November 1985). The analyzes are doubled. The percentage of total organic matter (MOT%) or volatile solid is obtained by weighing difference between the mass of the sample dried at 105 ° C and the mass of the sample after calcination. From this we can deduce the percentage of MOT in the dry and raw sample.

% MOT = $(M_1-M_2) / M_1 \times 100$ In the dry sample
% MOT = $(M_0-M_2) / M_2 \times 100$ In the raw sample

With: Mo: mass of the sample (g); M1: mass of the sample after passing through the oven (g); M_2: mass of the sample after calcination (g); % MOT: percentage of dry matter contained in the sample.

Carbon: To determine the evolution of carbon during the composting process we used the method of Walkey and Black (1934) reported by François (2004). The organic matter is cold oxidized by an excess of potassium dichromate (1 M) in an acidic medium (H_2SO_4). The dichromate which has not reacted with the organic matter is reduced by an excess of iron (II) (solution of double sulphate of ferrous iron and ammonium at 0.5 N) dosed in return with dichromate (1 M). The contents are deduced by considering 77% of the total oxidized organic carbon, and the approximation that 1 ml of dichromate corresponds to 3 mg of organic carbon. The percentage of organic carbon measured in the waste can be estimated from the following formula:$\%C_{org} = (x + (10-y)) \times 0.003 \times 100/77 \times 100/m$

With: m: mass of waste (g) x: volume of dichromate poured (ml) y: volume of dichromate used to titrate the solution of double ferrous iron and ammonium sulphate or Mohr's salt. The protocol indicates small samples of between 0.125 to 1 g of waste so that the dichromate used is reduced to 75%.

Nitrogen content: NTK nitrogen, the sum of ammoniacal nitrogen and organic nitrogen, is measured according to the Afnor ISO 11261 standard, June 1995. The samples dried at 105 ° C. are mineralized in a "mineralizer" for 1 hour at 180°C then for 2 hours at 360°C in an acidic medium and in the presence of a catalyst (K_2SO_4 and Se). The residues obtained after digestion are distilled after neutralization of the excess acid with 30% sodium hydroxide solution. The distillate is collected in an Erlenmeyer flask with hydrochloric acid (0.1M). The assay carried out with sodium hydroxide (0.1M) and methyl red makes it possible to determine the nitrogen contents of the sample. The masses of samples analyzed are low in the order of 0.1 g. The tests determined the most suitable amount of sample depending on the stage of ripening. This mass ranges from 0.1 to 1g. The larger the amount of sample, the longer the mineralization time will have to be. For an amount of 0.1g, the mineralization time is one hour at 180 ° C and two hours at 360 ° C. The NTK nitrogen content is expressed at ± 0.1 mg N-NTK / Kg Ms.

$$N - N \quad = \frac{(V_1 - V_0) \times 0{,}0 \quad \times C \times 1}{M} \text{ (mg N-NTK/Kg MS)}$$

With: V_0: volume of the sodium hydroxide solution used for the blank test (mL); V_1: volume of the soda solution used for the assay of the sample (mL); C: concentration of the sodium hydroxide solution used during the titration (mol/L); M: mass of the test sample (g).

C/N ratio: The change in the C / N ratio is often considered as an indicator of good degradation of a solid organic substrate during fermentation. This C/N ratio is calculated from the values of Corg measured by oxidation and the quantity of nitrogen N measured by the NTK method.

Determination of the metal content: The samples are hot mineralized with aqua regia (1/3 HNO3 + 2/3 HCl) according to the Afnor NF ISO 11 460 standard of June 1995. The compost is dried at 105 ° C and then crushed. Given the interference observed during the assay, and the very small sample weight (0.1 g), the analyzes are duplicated.

The samples are heated at 100 ° C for one hour and then at 135 ° C until the acid has evaporated, ie for about 3 hours. Adding distilled water brings the volume down to 50 ml. The samples are then filtered at 0.45 µm. Metal concentrations are measured either by furnace atomic absorption spectrophotometry for the majority of metals, or by flame atomic absorption spectrophotometry for zinc. The gas mixture used for the flame is air-acetylene. The device measures the difference in intensity between the incident radiation and that transmitted. Applying the Beer-Lambert law incorporating this difference provides access to the concentration of the compound. The detection limit of these two methods varies depending on the element dosed.

Maturity tests: The self-heating maturity test should be performed on waste, material undergoing fermentation and composts. The samples are sieved at 10mm. Their humidity is adjusted to a value obtained by the so-called "handle" test (F.C.Q.A.O, 1994). This test is described by a German standard (F.C.Q.A.O, 1994). A 1.5 L, 10 cm inner diameter Dewar is completely filled with the sample without active settlement. The open-top vessel containing the sample is placed in a thermostatically controlled chamber (20 ± 1 ° C). The temperature inside the vase is measured by a thermometer whose sensor is located about 20 cm below the surface of the compost. The duration of the test is 10 days. The maximum temperature reached (Tmax) allows to know the degree of maturity of the compost. This Dewar index varies from I(maximum temperature above 60°C) for compost assimilated to raw material, to V (maximum temperature below 30°C) for compost considered to be ripe and finished. Table 1 shows the test data.

Description of the site, infrastructure and equipment: The centre's infrastructure will include a composting platform, an organic fertilizer production area and a building for administration, employees and the laboratory. The main equipment consists of a wheel loader, a sieve for composting and sieving organic fertilizer, a shredder, a tank, a crusher for grinding the sludge, a system of pump and sprinkler, probe equipment and a mini laboratory.

Economic study

Investment cost

Costs of immobilization: They represent all the expenses incurred for the preparation of the land, the construction of the various buildings and the settling pond, etc. The purchase price of the land is not included in the capital costs since the pre-selected site is owned by the company. In order to be able to estimate the capital costs, we used some people in the capital field. We then added 10% to take into account unforeseen events.

Cost of equipment: It represents the amount spent on the purchase of different equipment. The prices were established on the basis of references from suppliers and contractors. Phone calls were also made to get the cost of certain equipment. We added 20% to account for any equipment that we could not determine the cost of or those that we forgot to determine the cost.

These expenses are frequently estimated at 20% of the total installed cost. Thus, the fixed capital or investment (I) is: $I = (C_i + C_e) \times 1.5$

With I: Fixed capital or investment (FCFA);
C_e: Cost of equipment (FCFA);
C_i: Capital cost (FCFA).

Operating costs: The operating costs correspond to the annual expenses incurred during the operation of the center. They include the costs of maintenance, labor, overheads, insurance, advertising, collection. The labor costs for a month of operation of the center are presented in Table 2. The costs of the other elements of the operation, namely maintenance, overheads and insurance, are given by the following relationships:

$Cm = 0.1 \times I$
$C_{FG} = 0.9 \times C_{mo}$
$C_A = 0.04 \times I$

With,Cm: cost of maintenance (FCFA / year); I: Fixed capital or investment (FCFA);

Cmo: labor cost (FCFA/year); C_{FG}: cost of overheads (FCFA/year); C_A: cost of insurance (FCFA/year).

Depreciation or endowment: Depreciation or endowment of equipment is the amount set aside for the return of equipment at the end of its life. The determination of this sum depends on the knowledge of the lifespan of the various equipment and infrastructures. Thus, depreciation is calculated by the following relationship: A = I/dv with: A: depreciation of equipment (FCFA); I: investment cost; dv: equipment lifespan (year) estimated at 35 years.

Cost of selling compost and organic fertilizer: The cost of sale for the first year of operation of the center is calculated from the annual production and the selling price of the products (compost and organic fertilizer) in Côte d'Ivoire. This is 6,000 FCFA for a 50 kg bag of compost or 120,000 FCFA/tonne and 110,000 CFA francs/tonne for organic fertilizer.

Evaluation of the center construction project: The evaluation of the construction project consists of studying the net present value or discounted profit (NPV), the internal rate of return (IRR) and the payback period of the invested capital.
Net present value (NPV). The NPV of the project is the difference between the discounted cash flows and the investment cost. It is expressed by the following relation:

$$NPV = C_0 \frac{1-(1+i)^{-n}}{i} - I$$

With:C0: cash flow;i: the discount rate which is 8%;I: the investment cost;n: lifespan of the center (year).

Internal rate of return (IRR): The internal rate of return x of the project is the rate for which the NPV is zero. The calculation of IRR is materialized by the following equation:

$$C_0 \frac{1-(1+x)^{-3}}{x} - I = 0 \text{ with:}$$

x: the internal rate of return; C_0: cash flow; I: the investment cost.

Investment payback period: The project investment payback time is the time after which the investment is paid back. It is calculated according to the following formula:

$d = \frac{\ln(1-\frac{i}{C_0})}{\ln(1+i)}$ with: C_0: the cash-flow; i: the discount rate which is 8%;I: the investment cost; d: payback period (year).

RESULTS AND DISCUSSION

Results of determination of supply quantities

Ash quantities: Table 3 below gives an estimate of the daily quantities of ash produced by the central oil mill. Table 3 gives an average ash production of about 2.41 tonnes/day. By doubling this figure, we deduce the average daily production of the three oil mills, which is 4.82 tonnes or 1759.3 tonnes per year. It can increase or decrease since it is a function of fuels.

Table 1. Dewar index values as a function of the maximum temperature reached

Fresh compost	Finished compost				
Tmax(°C)	60-70	50-60	40-50	30-40	<30
Dewar Index	I	II	III	IV	V

Sludge quantities

Determination of the daily wet sludge: The results of the daily sludge production are shown in Table 4 below:

Relation (1) made it possible to estimate the average daily sludge production of the three oil mills. It is around 54.474 tonnes per day or 54474 kg/day.

Table 2. Labor costs for the first month of operation of the center

Post	Base salary	Benefits social	Number of people	Total
Center manager	500 000	300 000	1	800 000
Technician	200 000	100 000	1	300 000
Operator	100 000	50 000	1	150 000
Workers	50 000	25 000	15	1 125 000

Table 3. Daily quantity of ash from the oil mill center

Days	Number of machining hours	Ash masses produced in tonnes
1	24 h	2,12
2	24 h	2,56
3	24 h	2,28
4	24 h	2,40
5	24 h	2,58
6	24 h	2,46
7	24 h	2,48

Table 4. Average daily sludge production of the three oil mills

Oil factories	Oil mill Central	Antenna 1	Antenna 2
Productions of the six months in tonnes	4 241,78	1 439,17	1 933,76
Day numbersmachining	151	106	151
Average in tonnes	28,091	13,577	12,806

Humidity rate: There are two clarification chains in the central oil mill, one older and the other new. The results of determining the moisture content of the sludge from these two chains are shown in tables 5 and 6 below:

Table 5. Moisture rate of samples from the old line

Sample number	Masses of samples before drying (g)	Masses of samples after drying (g)	Humidity rate (%)
1	10,015	2,728	72,76
2	10,019	2,753	72,52
3	10,018	2,740	72,65
4	10,008	2,766	72,36
5	10,000	2,753	72,47

Table 6. Moisture rate of the sludge samples from the new chain

Sample number	Masses of samples before drying (g)	Masses of samples after drying (g)	Humidity rate (%)
1	10,054	1,709	83,00
2	10,012	1,704	82,98
3	10,009	1,697	83,04
4	10,031	1,698	83,07
5	10,034	1,696	83,10

Tables 5 and 6 give an average humidity rate of 72.55% for the old chain and 83.04% for the new chain. These results show that the mud from the new chain contains a lot of water, unlike that from the old clarification. From these results, we deduce the average moisture content of the mud which is approximately 77.795%.

Dry matter: Relation (3) made it possible to estimate the daily production of dry matter. It is 12,096 tonnes per day, or 4415.04 tonnes / year or 12,096 kg / day.

Quantity of stalks: The results of the determination of the quantity of cobs produced are given in Table 7 below:

Table 7. Average daily stalk production of the three oil mills

Oil Factories	Oil mill Central	Antenna 1	Antenna 2
Productions of the sixmonths in tonnes	36 358,14	12 335,30	16 575,17
Day numbers machining	151	106	151
Average in tonnes	240,782	116,371	109,769

The daily quantity of cobs produced by the three factories is approximately 466.922 tonnes or approximately 170,426.53 tonnes / year. It can increase or decrease depending on the period.

Forecast of the centre's annual production

Forecast of the compost center's annual production: Using the swathing method, we estimate the center's annual production at 20,000 tonnes of compost. This number may increase or decrease depending on the optimization of the process.

Forecast of the centre's annual production of organic fertilizer: Taking into account the various predefined factors and assuming that all quantities of sludge and ash will be transformed into organic fertilizer, the estimated production is approximately 6,174.34 tonnes of fertilizer per year.

Table 8. Chemical compositions of ash and different sludges

PARAMETERS	UNIT	SAMPLES REFERENCES / RESULTS		
		NEW DRY MUD CLARIF	OLD DRY MUD CLARIF	ASH FROM THE BOILER
Potassium	gK/ kg	6,63	1,60	19,8
Calcium	gCa/ kg	2,38	2,23	7,54
Magnesium	gMg/ kg	2.12	1,49	12,1
Nitrite	mgNO_2/ kg	0,193	0,699	2,39
Nitrate	mgNO_3/ kg	19,1	45,1	12,6
Phosphates	mgPO_4/ kg	96,9	77,7	33,9
Ammonium	mgNH_4/ kg	< 0,1	$2{,}91.10^2$	$5{,}82.10^2$
Total phosphorus	mgP/ kg	$1{,}62.10^3$	$1{,}19.10^3$	$1{,}02.10^4$
NTK	mgN/ kg	$2{,}20.10^4$	$1{,}79.10^4$	$3{,}02.10^2$

Table 9. Results of the economic evaluation

NPV (FCFA)	IRR (%)	Payback period (years)
20 176 567 240	128,6	0,83

Analysis results: The results of the analyzes of the ash and of the various sludges are given in Table 8 below. Table 8 shows us that sludge and ash contain nutrients such as nitrogen, phosphorus, potassium (N, P, K) and many more. The significant presence of these elements shows that these elements could contribute to soil amendment, thus serving as fertilizer for plants. Therefore, ash and mud could be used as raw materials for the production of organic fertilizer.

Economic study

Investment cost or fixed capital

The sum of the total equipment and capital costs is 1,202,188,636. FCFA or approximately 1,202,188,700 FCFA. Thus the fixed capital is 1,442,626,440 FCFA, or 1,442,626,500 FCFA. This capital may vary depending on the fluctuation of equipment prices on the market.

Operating costs: The estimation of the costs of advertising, collection and labor as well as the calculation make it possible to estimate the operating costs. The operating costs of the center are estimated at 553 330 080 FCFA / year, or about 553 330 100 FCFA.

Depreciation or endowment: The calculated depreciation of equipment is 41,217,898.29 FCFA, or approximately 41,217,900 FCFA. This value found, constitutes the annuity of depreciation. It is a non-disbursable charge. It will thus be used to refinance the centre's equipment at the end of its life.

Cost of selling compost and organic fertilizer: For an annual production of 20,000 tons / year, the compost wind cost calculated for the first year is estimated at 2,400,000,000 FCFA. An estimate of the wind cost of organic fertilizer is 679,177,400 FCFA with an annual production of 6,174.34 tons. Thus, the center’s turnover is around 3,079,177,400 FCFA. This figure may vary with the different annual productions of the products.

Evaluation of the center construction project: Determining the three evaluation criteria for this project (NPV, IRR and payback time) yielded the following results. The NPV is estimated at 20,176,567,240 FCFA. Since the NPV is positive, the project is profitable. The IRR obtained is greater than the discount rate i (8%). The project is therefore profitable.

The IRR analysis confirms the profitability of the project initially studied by the NPV. The invested capital is recovered within 0.83 years or approximately 8 months 3 days. The payback period also measures the risk that the promoter (in our case PALMCI EHANIA) runs in recovering his investment within a period of time compared to the amortization period of the project. It would be advisable for this period not to exceed four-fifths (80%) of the amortization period, otherwise the risk becomes great beyond that. We calculate the d / dv ratio (d is the payback period and dv the amortization period) to assess this risk.

$d/dv = 1.82/35 = 0.024$

The d/dv ratio (2.4%) of the project is less than 80%, so the risk is lower. The project is then profitable.

DISCUSSION

This study showed that: the average ash production of the center is 2.41 tons/day, that of sludge is about 54.474 tons/day, with an average moisture content of the sludge of about 77.795%. In addition, the daily production of dry matter is 12,096 kg/day with a daily quantity of cobs of about 466.922 tonnes or about 170,426.53 tonnes/year. This shows that there is an opportunity to set up a composting unit with a nominal compost production of 20,000 tonnes and that of organic fertilizer of 6,174.34 tonnes.

ADEME and AMORCE (2012) similarly concluded that whatever the technique used, most of the composts obtained are relatively of good quality: dry matter content between 35 and 70%, very low organic pollutant load, neutral pH, stable product and agronomic quality. These results are comparable to those of Misra et al (2005). This concludes that the drum used for the production of compost is about 3.35 m in diameter and 36.58 m long has a daily capacity of 50 tonnes with a residence time of three days. The financial indicators, namely the NPV, the IRR and the capital recovery time, respectively 20,176,567,240 FCFA, 128.6% and 0.83 years, are excellent. Theseresults are in agreement with those of Marcel Boyer in 2017. The latter affirms that a project with a profitability index greater than 1 implies that the current value of fixed costsis greater than the initial investment, hence a positive NPV for the project.

Conclusion

At the end of our study carried out for the establishment of a composting and organic fertilizer production center, it appears that there is an opportunity to set up a composting unit at PALMCI EHANIA. Its nominal compost production will be 20,000 tonnes. And that in organic fertilizer will be 6,174.34 tons. The financial indicators, namely theNPV, the IRR and the capital recovery time, respectively 20,176,567,240 FCFA, 128.6% and 0.83 years, are excellent.The project aims to manage all of the waste produced by UAI's oil mills in EHANIA in order to provide growers with new opportunities to improve their yields. In addition, the great flexibility of supply and delivery of compost and organic fertilizer that the center will offer, will secure the production of organic amendment in PALMCI EHANIA and in the Region.

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